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CA80-15 as a gamma dosimeter

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Recent studies (Frank and Benton 1970, Nicolae 1973, Vareille *et al* 1975, Khan *et al* 1975, Varnagy 1978, Akbar *et al* 1980, Zamani and Charalambous 1985, Portwood and Henshaw 1986, Zamani *et al* 1986) show that the etching characteristics of plastic track detectors are greatly modified by their exposure to high doses of gamma radiation or X-rays. The modifications in etching characteristics originate from the structural alterations produced by the radiation doses in the plastic.

The exposure of plastics to gamma radiation causes cross-linking and degradation. The studies on the intrinsic viscosity (Ancierno *et el* 1980) show that CA80-15 plastic track detector predominantly undergoes degradation at gamma doses higher than 1 Mrad. Since the chemical etch rate is directly affected by the degradation, the gamma dose dependence of the bulk etch rate of CA80-15 is understood to provide a reasonably accurate estimation of the unknown gamma doses.

Present work aims at finding out the relationship between the bulk etch rate and gamma dose for CA80-15 over the high gamma dose range 2-20 Mrad.

Sheets of CA80-15, produced by Kodak-Pathe of France, having a thickness of 100 μm were irradiated by gamma rays from a ^{60}Co gamma cell unit. The dose rate of the gamma cell unit was (40 $\pm$ 2) krad per hour. The different irradiated samples were etched under different etching conditions and with each irradiated sample a non-irradiated sample was also used to monitor the etching conditions. The etching was carried out at 40°C, 45°C and 50°C and at each of these temperatures for KOH normalities 3N, 5N, 7N and 9N. At each etching condition, the etching was carried out in the steps of 10 minutes. After etching for 10 minutes, the samples were rinsed in distilled water, washed thoroughly for about 15 minutes and then dried in a dust free space. The procedure was repeated several times to etch out a thickness of the order of 10 μm. The number of steps required to etch out a thickness of this order depends upon the etching condition and gamma dose. For an unirradiated detector sample at the etching temperature 40°C and for normality 3N, the above procedure was repeated eighteen times to remove a layer of about 9.7 μm thickness from one surface of the detector sample whereas for an irradiated sample to gamma dose of 10 Mrad at etching temperature 50°C and for normality 5N, only two times repetition of the above procedure resulted in a removal of about 12.1 μm thickness from one surface. Finally, the bulk etch rate (V_B) was determined by both the thickness measurement using Michelson Interferrometer and the mass measurement by an analytical balance. The results of the two methods agree well within the experimental uncertainties. The order of uncertainties in the method by mass measurement is 0.01 μm/hr and that in the method by thickness measurement is 0.1 μm/hr.

Figure 1 shows the variation of the bulk etch rate (V_{BD}) with gamma dose

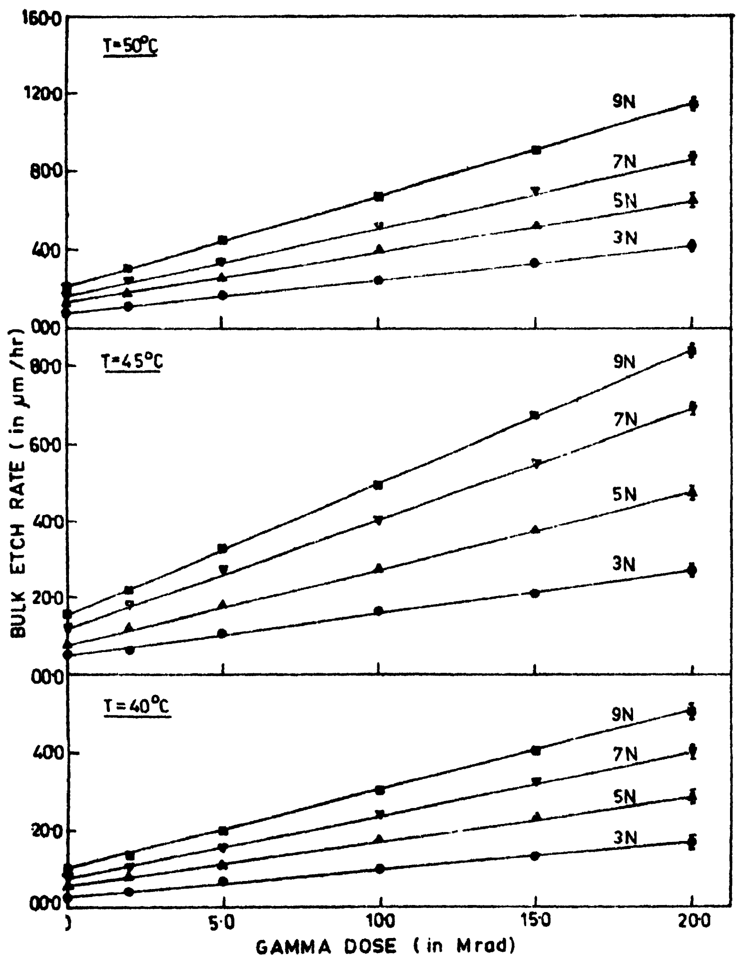

Figure 1. Variation of the bulk etch rate (V_{BD}) with gamma dose (D) for cellulose nitrate (CA80−15) track detector at different etching conditions.

for different etchant concentrations and at temperatures 40°C, 45°C and 50°C. Continuous lines are the best fits to the experimental points. Clearly, V_{BD}

increases linearly with gamma dose at all the etching conditions. Khan *et al* (1975) also found similar variation for V_{BD} with gamma dose at the standard etching conditions (50°C, 6.25N NaOH). The linear relationship for all etching conditions, studied in the present work, can best be expressed as :

$$V_{BD}=(0.22D+1.00)V_{BO} \tag{1}$$

where

V_{BD} = the bulk etch rate with gamma dose

D = the gamma dose in Mrad

V_{BO} = the bulk etch rate without dose

The linear increase of V_{BD} with gamma dose shows that the irradiation of CA80-15 to high gamma doses (dose > 2 Mrad) produces mainly, the main chain scission. The relationship also suggests the simple use of CA80-15 as a gamma dosimeter. The method involves three steps :

– Determination of V_{BD} versus D calibration curve.

– Determination of V_{BD} for the gamma irradiated samples of unknown doses.

– Reading off D from the calibration curve.

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